

### Dave Pushka's Block Raiser (Pivoter) Calculations for variable geometry

#### Detector Block Weights and

#### Dimensions and Loads to Table:

Weight of a block	312,979 pounds	156.5 tons (short)
Nominal Thickness of a block	2053.6 millimeters	80.85 inches
Nominal Thickness of a block		
Nominal H or W of a Block	15.7 m	618.110236 in
Volume of Block	17,876 ft <sup>3</sup>	51.5091863 ft
Apparent Density of Empty Block		17.5 #/ft <sup>3</sup>
Block loading on table when horizontal		117.96 #/square foot

#### Geometry of Table Pivot:

Goal Distance from table top to pivot (vertical direction when table horizontal)	4 inches	positive means that the pivot is below the top surface of the table when the table is horizontal
Vertical Distance from pivot to block c.g. when table is horizontal	44.425 inches	equals half the thickness of a block plus the goal distance from the table top to the pivot shown right above
Horizontal Distance from Pivot to block c.g. when table is horizontal (positive number is toward the forks) L_block = Distance from block c.g. to pivot, inches	0.000 inches	zero indicates that the pivot is right under the block c.g., positive means that the pivot is towards the forks
L_table = Distance from table c.g. to pivot, inches	44.425 inches	calculated by the square of the sum of the squares.
	20.1875 inches	calculated by the square of the sum of the squares.

#### Moments Generated by the Block

#### Weight on the Table When Vertical:

Moment from block weight about pivot when table is vertical	13,904,173 inch-pounds	1,159 kip-ft
Theta0_Block is the initial angle above horizontal from the pivot to the block c.g.	1.571 radians	90.0 degrees
Theta0_Table is the initial angle above horizontal from the pivot to the table c.g.	-1.571 radians	-90.0 degrees

Moment from block weight on the table 'forks' when the block is vertical	12,652,255 inch-pounds	1,054 kip-ft	this is the maximum bending moment at the base of the 'forks' supporting the cantilevered block.
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Moments as a Function of the table rotation (0=table horizontal):	Angle from table pivot to block c.g. (from horizontal)										Cosine of Angle to block c.g.	Cosine Angle to table c.g.	Block Weight pounds	Table Weight pounds	Block Distance to Pivot	Table Distance to Pivot	Moment Due to Block (cw = +) in-lbs	Moment Due to Table (cw = +) in-lbs	Moment Due to Block and Table (cw = +) in-lbs	Sum of Moments from Block and Table (cw = +) in-lbs
	Table Angle (top surface above horizontal) degrees	Table Angle (top surface above horizontal) radians	Angle from table pivot to block c.g. (from horizontal) degrees	Angle from table pivot to block c.g. (from horizontal) radians	Angle from table pivot to table c.g. (from horizontal) degrees	Angle from table pivot to table c.g. (from horizontal) radians	Block Weight pounds	Table Weight pounds	Block Distance to Pivot	Table Distance to Pivot										
Table Angle above horizontal (degrees and radians):	0	0	90	1.57	-90	-1.571	0.0000	0.0000	312,979	122,655	44.425	20.1875	31	12	44					
	15	0.2618	105	1.83	-75	-1.309	-0.2588	0.2588	312,979	122,655	44.425	20.1875	-3,598,634	640,875	-2,957,759					
	30	0.5236	120	2.09	-60	-1.047	-0.5000	0.5000	312,979	122,655	44.425	20.1875	-6,952,059	1,238,064	-5,713,995					
	45	0.7854	135	2.36	-45	-0.785	-0.7071	0.7071	312,979	122,655	44.425	20.1875	-9,831,713	1,750,881	-8,080,832					
	60	1.0472	150	2.62	-30	-0.524	-0.8660	0.8660	312,979	122,655	44.425	20.1875	-12,041,351	2,144,378	-9,896,974					
	75	1.3090	165	2.88	-15	-0.262	-0.9659	0.9659	312,979	122,655	44.425	20.1875	-13,430,392	2,391,739	-11,038,653					
	90	1.5708	180	3.14	0	0.000	-1.0000	1.0000	312,979	122,655	44.425	20.1875	-13,904,173	2,476,107	-11,428,066					
	90	1.5708	180	3.14	0	0.000	-1.0000	1.0000	0	122,655	0	20.1875	0	2,476,107	2,476,107					
	75	1.3090	165	2.88	-15	-0.262	-0.9659	0.9659	0	122,655	0	20.1875	0	2,391,739	2,391,739					
	60	1.0472	150	2.62	-30	-0.524	-0.8660	0.8660	0	122,655	0	20.1875	0	2,144,378	2,144,378					
	45	0.7854	135	2.36	-45	-0.785	-0.7071	0.7071	0	122,655	0	20.1875	0	1,750,881	1,750,881					
	30	0.5236	120	2.09	-60	-1.047	-0.5000	0.5000	0	122,655	0	20.1875	0	1,238,064	1,238,064					
	15	0.2618	105	1.83	-75	-1.309	-0.2588	0.2588	0	122,655	0	20.1875	0	640,875	640,875					
	0	0	90	1.57	-90	-1.571	0.0000	0.0000	0	122,655	0	20.1875	0	12	12					

### Forces on a Cylinder Resulting from the above Moments:

Horizontal Location of Cylinder Top w.r.t Table Pivot	-72.0001 inches	positive is towards the forks
Vertical Location of Cylinder Top w.r.t. Table Pivot	-72 inches	positive is up
Horizontal Location of Cylinder Bottom w.r.t Table Pivot	-72 inches	positive is towards the forks
Vertical Location of Cylinder Bottom w.r.t. Table Pivot	-167.0001 inches 95 inches	positive is up
Closed Length of the cylinder Radius from Table Pivot to top of cylinder point	101.82 inches	
Initial Angle above horizontal from Table Pivot to top of cylinder point	-0.785 radians	
Initial Angle above horizontal from Table Pivot to top of cylinder point	-45.00003979 degrees	
Length of the 'ground' link from table pivot to stationary cylinder end pivot at the bottom of the cylinder	181.9 inches	
Fixed Angle above horizontal from Table Pivot to bottom of cylinder end pivot, Theta	-66.67731577 degrees	
Initial Angle between the 'ground' link and the line (r) from the table pivot to the top of the cylinder, Lambda	21.67727598 degrees	

	Table Angle (top surface above horizontal degrees)	Sum of Moments from Block and Table (cw = +)						Vertical Lever Arm to Cylinder Top inches	Horizontal Lever Arm to Cylinder Top inches	Hydraulic Cylinder Force (- = tension, + = compression) pounds		Hydraulic Cylinder Force (- = tension, + = compression) tons	
		Moments from Block	Vertical Component of Cylinder Extension	Horizontal Component of Cylinder Extension	Cylinder Extension	Cylinder Angle c.w. from vertical degrees							
On the way Up: (with block Load)	0	44	0.00	0.00	0	0.000	72.00	72.00	72.00	1	0.0		
	15	-2,957,759	21.09	16.18	27	7.648	50.91	88.18	-31,408	-15.7			
	30	-5,713,995	45.65	26.35	53	10.278	26.35	98.35	-56,308	-28.2			
	45	-8,080,832	72.00	29.82	78	9.931	0.00	101.82	-80,568	-40.3			
	60	-9,896,974	98.35	26.35	102	7.695	-26.35	98.35	-105,355	-52.7			
	75	-11,038,653	122.91	16.18	124	4.238	-50.91	88.18	-131,134	-65.6			
	90	-11,428,066	144.00	0.00	144	0.000	-72.00	72.00	-158,723	-79.4			
On the way down: (without block load)	90	2,476,107	144.00	0.00	144	0.000	-72.00	72.00	34,390	17.2			
	75	2,391,739	122.91	16.18	124	4.238	-50.91	88.18	28,413	14.2			
	60	2,144,378	98.35	26.35	102	7.695	-26.35	98.35	22,827	11.4			
	45	1,750,881	72.00	29.82	78	9.931	0.00	101.82	17,457	8.7			
	30	1,238,064	45.65	26.35	53	10.278	26.35	98.35	12,200	6.1			
	15	640,875	21.09	16.18	27	7.648	50.91	88.18	6,805	3.4			
	0	12	0.00	0.00	0	0.000	72.00	72.00	0	0			

**Dave Pushka's Block Raiser (Pivoter) calculations for the top table made from plate steel:****Initial Guesses:**

Assumed weight of table	300,000 pounds
Required Distance from pivot to table c.g. if the table is to balance the block when the block is vertical	46.3 inches
Required thickness of table assuming homogenous	100.7 inches

**Table Dimensions and Thicknesses:**

Thickness of Table Top Plates	3/16 inches
Thickness of Table bottom plates	0.1875 inches
Thickness of table vertical shear webs	0.1875 inches
No. of shear webs in the beam direction	26
No. of shear webs perpendicular to the beam direction	26
Distance between shear webs in beam direction	1.981 feet
Distance between shear webs perpendicular to the beam direction	1.981 feet
Thickness of table shear plates in the vertical direction when horizontal	4 feet
Weight of Table Top in pounds per square foot	7.656 pounds per square foot
Weight of Table Bottom in pounds per square foot	7.656 pounds per square foot
Weight of shear webs in pounds per square foot	7.656 pounds per square foot

**Table Weight:**

Weight of Table Top in pounds	20,314 pounds
Weight of Table Bottom in pounds	20,314 pounds
Weight of Table shear webs in pounds	82,028 pounds
Weight Sub Total	122,655 pounds
Assumed Number of Table Pieces for Shipping	6
Table Piece Width, feet	8.585 feet
Table Piece Weight, pounds	20,443 pounds

**Table C.G.**

Distance from Table Top Surface to Top Plate c.g.	0.09375 inches
Distance from Table Top Surface to Bottom Plate c.g.	48.28125 inches
Distance from Table Top Surface to Shear Plate c.g.	24.1875 inches
Table Top Contribution to c.g.	1,904 inch pounds
Table Bottom Contribution to c.g.	980,763 inch pounds
Table Shear Contributions to c.g.	1,984,061 inch pounds
Sub Total of Contributions to c.g.	2,966,729 inch pounds
Sum of Contributions divided by weight	24.188 inches

**Moments Generated by Table****Weight about Pivot When Vertical:**

Goal Distance from table top to pivot  
(vertical direction when table horizontal)  
Distance from Table Pivot to c.g.                  4 inches  
    20.188 inches

Moment Generated by Table Weight  
about Pivot when table is vertical:  
    2,476,107 inch-pounds

Moment Generated by Table Weight  
about Pivot when table is vertical:  
    206 kip-ft

**Sum of Moments about Table Pivot****When Vertical:**

Moment Generated by Table Weight  
about Pivot when table is vertical:  
    2,476,107 inch-pounds  
Moment from block weight about  
pivot when table is vertical                        (13,904,173) inch-pounds

Moment Sum when table is vertical:  
    (11,428,066) inch-pounds

Moment Sum when table is vertical:  
    (952,339) foot-pounds

This means that the table provides  
more of a moment about the pivot  
than the complete block does. This  
moment tends to make the loaded  
table move to the horizontal position.

Assumed Distance from Pivot to  
Cylinder Connection in the horizontal  
Direction, feet                                        4 feet

Number of Cylinders acting together                2  
Initial Cylinder Load when loaded  
table is horizontal                                    pounds

**Moment of Inertia for the Table:**

Top and Bottom Plates:

Follow sketch of un-equal rectangles  
on AISC 9th Ed. ASD Pg. 6-19

b = b1 = table width in inches =

b9\*12

618.1 inches

t = top plate thickness = b26

0.1875 inches

t1 = bottom plate thickness = b27

0.19 inches

d1 = shear plate depth = b33

48.0 inches

A = b\*t + b1 \* t1

231.8 in^2

c = ((0.5\*b\*t^3) + (b1\*t1\*(d-0.5\*t1))/A

24.19 inches

y = c - t/2

24.09 inches

d =

48.38 inches

c1 = d - c

24.28 inches

y1 = c1 -(t1/2)

24.19 inches

I =((b\*t^3)/12) + b\*t\*(y^2) +

135,082 inches^4

((b1\*t1^3)/12) + b1\*t1\*(y1^2)

Web Plates:

bw = Web thickness, inches

0.1875 inches

dw = Web depth, inches

48 inches

Iw - moment of inertia for one web

1728 inches^4

Number of webs:

26

Iw total, I for all the webs combined

44,928 inches^4

Aweb = the area of one web,

inches^2

Aweb total = the area of all webs

combined, inches^2

234 inches^2

Combining the Top and Bottom  
Plates and the Webs:

dna = distance from the n.a. of the

top &amp; btm to the n.a. of the web

Moment of inertia of the web about

the n.a. of the top and bottom plates

= Iw total + dna^2\*Aweb total

44,928 inches^4

Icomb = I (top&amp;btm) + I web (w.r.t.

top &amp; btm n.a.)

y = dimension from n.a. to extremum

fiber = c, inches

24.19 inches

**Bending Stresses on the Table****when horizontal:**

Let the beam direction be called 'x'  
 Let the direction perpendicular to the beam be called 'y'

In the x direction, the uniform load is from both the block and the table weight.

Block weight 312,979 pounds

Table Weight 122,655 pounds

Sum of Block and Table weights: 435,635 pounds

Area of Table (based on L x W from above) 2653.2 ft<sup>2</sup>

Uniform Load on Table 164.19 pounds per square foot

Uniform Load on Table per unit Length

8.457 pounds per foot

Bending Moment on Table 2,804,900 foot-pounds Moment, M = uniform load, w, \* ((the table length/2)<sup>2</sup>)<sup>2</sup>/2

Bending Moment on Table 33,658,797 inch-pounds

Bending Moment on Table 33,659 kip-in

**Bending Moments about 'y':**

One simple support at the center of the table, cantilevered up stream and downstream directions.

$$M=(wL^2)/8 \text{ where}$$

Bending stress, Sigma = My/I

Bending Moment on Table 33,658,797 inch-pounds

Distance to extreme fiber, y (inches) 24.19 inches

Moment of Inertia, combined table section, I<sub>comb</sub> 180,010 inches<sup>4</sup>

Bending Stress, sigma, (psi) 4,523 psi

| Table Depth (inches) |
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72.515625 72.515625 48.515625 48.515625 24.421875 24.421875

**Deflection of Tablewhen****Horizontal:**

In the beam direction, x where the table is cantilevered, the deflection of the far end is:  $\delta_{far} = \frac{w l^4}{8EI}$

w = uniform distributed load

l = length = the length of the

cantilever = half the table length

Young's Modulus, E (psi)

Moment of Inertia, combined table

section, I<sub>comb</sub>      309.1 inches<sup>4</sup>

29,000,000 psi

delta1 = 0.15396267 inches

Fraction of the deflection due to the

block loads

Magnitude of the deflection due to

the block loads

0.1106 inches

If a support were added to the ends of the table to change the beam from cantilevered to the loading shown on AISC 9th Edition Page 2-299, Case 12, In the beam direction, the deflection of the far end is:  $\delta_{far} = \frac{w l^4}{185EI}$

w = uniform distributed load

l = length = the length of the

cantilever = half the table length

Young's Modulus, E (psi)

Moment of Inertia, combined table

section, I<sub>comb</sub>      309.1 inches<sup>4</sup>

29,000,000 psi

delta1 = 0.00666 inches

Fraction of the deflection due to the

block loads

Magnitude of the deflection due to

the block loads

0.00478 inches

Plate Thickness (inches)	Table Weight (pounds)	Table Deflection (in)	Peak Bending Stress (psi)	Table Deflection (in)	Peak Bending Stress (psi)	Table Deflection (in)	Peak Bending Stress (psi)
3/16	122,655	0.1540	4,523				
1/8	109,113	0.0888	3,896	0.2099	6,149	0.8872	13,065
5/32	136,391	0.0756	3,318	0.1763	5,173	0.7336	10,831
3/16	163,670	0.0667	2,933	0.1540	4,523	0.6311	9,341
7/32	190,948	0.0604	2,658	0.1380	4,058	0.5577	8,276
1/4	218,226	0.0557	2,451	0.1259	3,709	0.5026	7,477
9/32	245,504	0.0520	2,291	0.1166	3,438	0.4596	6,856
5/16	272,783	0.0490	2,163	0.1091	3,221	0.4252	6,358
11/32	300,061	0.0466	2,058	0.1029	3,043	0.3969	5,950

w = uniform distributed load

l = length = the length of the

cantilever = half the table length

Young's Modulus, E (psi)

Moment of Inertia, combined table

section, I<sub>comb</sub>      309.1 inches<sup>4</sup>

29,000,000 psi

delta1 = 0.15396267 inches

Fraction of the deflection due to the

block loads

Magnitude of the deflection due to

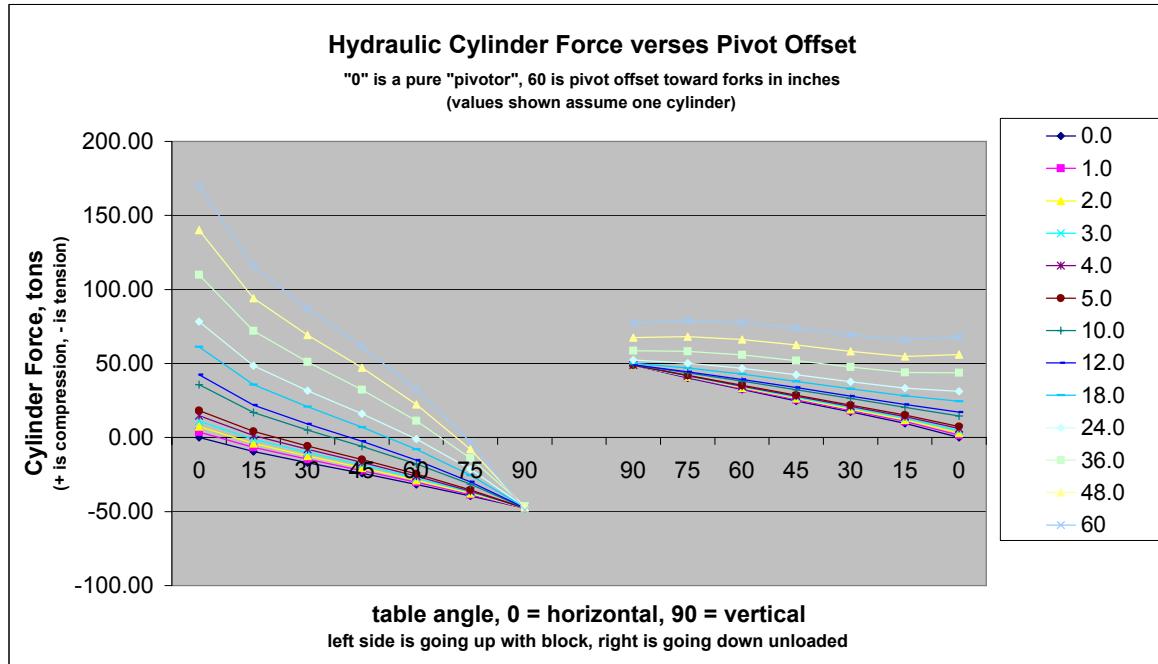
the block loads

0.1106 inches

**Analysis of the Pivot Position and the resulting Hydraulic Cylinder Loads:**

Horizontal Distance from Pivot to  
block c.g. when table is horizontal  
(positive number is toward the forks)

		0.000	0.0	1.0	2.0	3.0	4.0	5.0	10.0	12.0	18.0	24.0	36.0	48.0	60
		inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches
		Hydraulic Cylinder Force (- = tension, + = compression) (top surface above horizontal) degrees	Hydraulic Cylinder Force (- = tension, + = compression) (horizontal) Compression n)												
On the way Up: (with block Load)	0	0.0	0.00	3.69	7.37	11.03	14.68	18.29	35.76	42.41	61.15	78.34	109.97	140.08	169.88
	15	-15.7	-9.44	-6.71	-3.99	-1.29	1.40	4.07	16.99	21.91	35.81	48.59	72.02	94.11	115.76
	30	-28.2	-16.92	-14.65	-12.39	-10.14	-7.90	-5.68	5.08	9.19	20.82	31.53	51.10	69.34	87.00
	45	-40.3	-24.20	-22.33	-20.46	-18.60	-16.75	-14.92	-12.61	-7.07	16.01	32.25	47.16	61.35	
	60	-52.7	-31.65	-30.24	-28.83	-27.42	-26.02	-24.64	-17.90	-15.30	-7.91	-1.05	11.32	22.37	32.57
	75	-65.6	-39.39	-38.58	-37.76	-36.95	-36.14	-35.34	-31.42	-29.89	-25.47	-21.33	-14.01	-7.96	-2.89
	90	-79.4	-47.68	-47.68	-47.68	-47.68	-47.68	-47.68	-47.61	-47.54	-47.22	-46.81	-46.43	-47.17	-49.01
On the way down: (without block load)	90	17.2	48.87	48.87	48.87	48.88	48.88	48.89	49.06	49.24	50.31	52.31	58.74	67.43	77.46
	75	14.2	40.38	40.71	41.05	41.38	41.72	42.05	43.75	44.48	47.00	50.13	58.22	68.10	79.10
	60	11.4	32.44	33.02	33.60	34.18	34.75	35.32	38.13	39.26	42.79	46.69	55.76	66.21	77.57
	45	8.7	24.81	25.58	26.34	27.11	27.87	28.62	32.28	33.71	37.99	42.40	52.03	62.64	73.96
	30	6.1	17.34	18.27	19.20	20.12	21.04	21.95	26.33	28.02	32.92	37.75	47.72	58.31	69.41
	15	3.4	9.67	10.79	11.91	13.01	14.12	15.21	20.44	22.42	28.06	33.41	43.94	54.68	65.72
	0	0.0	0.00	1.51	3.03	4.53	6.02	7.49	14.53	17.17	24.52	31.23	43.75	55.97	68.23

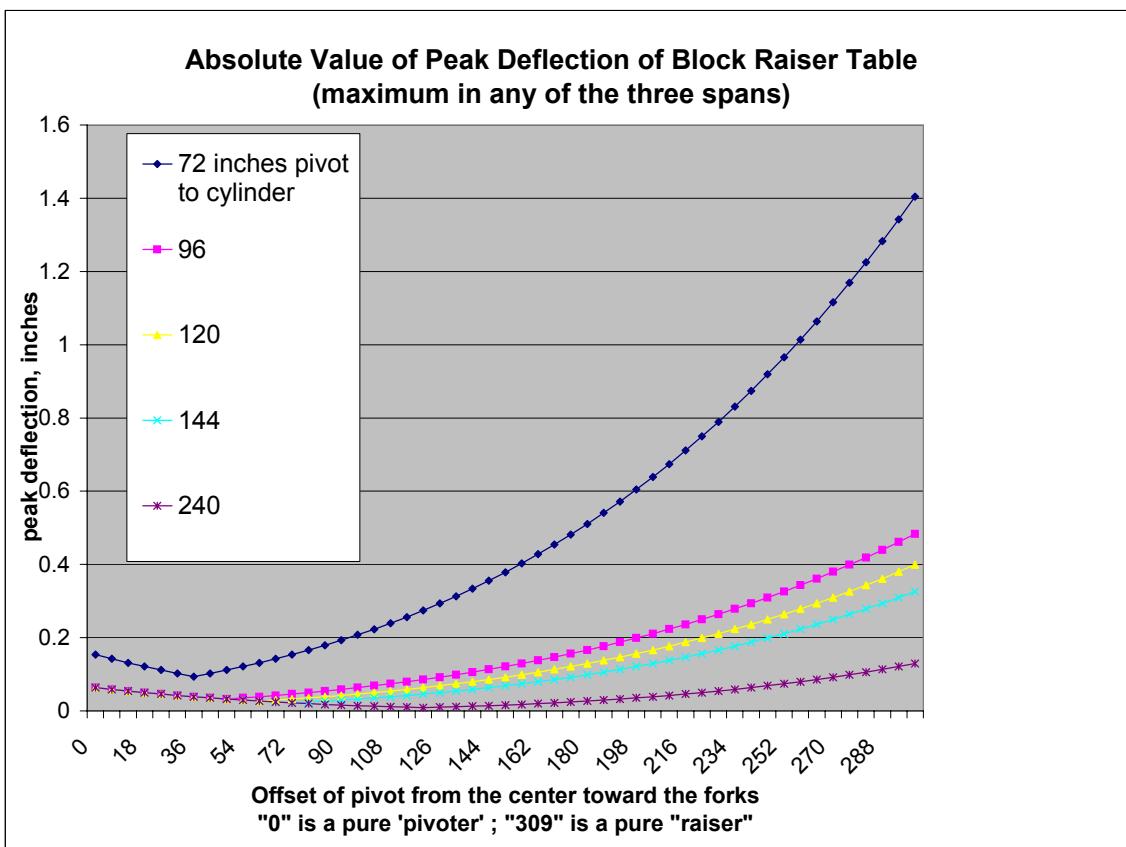


#### **Analysis of the Pivot Position and the resulting Table Stresses and Deflections::**

Consider the case where the table is horizontal, supported by the pivot and the hydraulic cylinder:

w = uniform distributed load      8,457 pounds per foot      705 pounds per inch  
l = length = the length of the cantilever      309 inches  
Young's Modulus, E (psi)      29,000,000 psi  
Use the moment of inertia (Icomb)  
calculated above:      180,010 inches<sup>4</sup>  
Horizontal Location of Cylinder  
Bottom w.r.t Table Pivot      -72 inches      positive is towards the forks

Pivot Offset from the center of the table toward the forks: (inches)	Length of center span between cantilever on the fork end (inches)	Length of center span between pivot and cylinder (inches)	Length of cantilever on the end away from the forks (inches)	Moment in the fork end cantilever (M = wI^2/2) (in-pounds)	Moment in the cantilever on the end away from the forks (M = wI^2/2) (in-pounds)	Moment in the center span between pivot and cylinder M=(wI^2/8)- (m1+M2)/2 + (M1- M2)^2/2wl^2 (kip-in)	Deflection at the fork end cantilever (delta = wl^4/8EI) (inches)			Deflection in the center span between pivot and cylinder Delta= (inches)	Deflection of the cantilever on the end away from the forks (M = wl^2/2) (inches)		
							wl^2/8	(M1+M2)/2	((M1- M2)^2)/2wl^4 2)				
0	309	72	237	33,658,797	19,802,744	0	456,701	26,730,771	26,274,070	0	0.154	-0.0033	0.053
6	303	72	243	32,364,579	20,817,868	-7,888,641	456,701	26,591,223	18,245,882	-7,888,641	0.142	-0.0033	0.059
12	297	72	249	31,095,732	21,858,364	-14,342,983	456,701	26,477,048	11,677,364	-14,342,983	0.131	-0.0032	0.065
18	291	72	255	29,852,258	22,924,232	-19,363,027	456,701	26,388,245	6,568,518	-19,363,027	0.121	-0.0032	0.071
24	285	72	261	28,634,157	24,015,472	-22,948,773	456,701	26,324,815	2,919,341	-22,948,773	0.111	-0.0032	0.078
30	279	72	267	27,441,427	25,132,085	-25,100,220	456,701	26,286,756	729,835	-25,100,220	0.102	-0.0032	0.086
36	273	72	273	26,274,070	26,274,070	-25,817,369	456,701	26,274,070	0	-25,817,369	0.094	-0.0032	0.094
42	267	72	279	25,132,085	27,441,427	-25,100,220	456,701	26,286,756	729,835	-25,100,220	0.086	-0.0032	0.102
48	261	72	285	24,015,472	28,634,157	-22,948,773	456,701	26,324,815	2,919,341	-22,948,773	0.078	-0.0032	0.111
54	255	72	291	22,924,232	29,852,258	-19,363,027	456,701	26,388,245	6,568,518	-19,363,027	0.071	-0.0032	0.121
60	249	72	297	21,858,364	31,095,732	-14,342,983	456,701	26,477,048	11,677,364	-14,342,983	0.065	-0.0032	0.131
66	243	72	303	20,817,868	32,364,579	-7,888,641	456,701	26,591,223	18,245,882	-7,888,641	0.059	-0.0033	0.142
72	237	72	309	19,802,744	33,658,797	0	456,701	26,730,771	26,274,070	0	0.053	-0.0033	0.154
78	231	72	315	18,812,993	34,978,388	9,322,939	456,701	26,895,690	35,761,929	9,322,939	0.048	-0.0033	0.166
84	225	72	321	17,848,614	36,323,351	20,080,176	456,701	27,085,982	46,709,458	20,080,176	0.043	-0.0033	0.179
90	219	72	327	16,909,607	37,693,686	32,271,712	456,701	27,301,647	59,116,658	32,271,712	0.039	-0.0033	0.193
96	213	72	333	15,995,973	39,089,394	45,897,545	456,701	27,542,683	72,983,528	45,897,545	0.035	-0.0034	0.208
102	207	72	339	15,107,710	40,510,474	60,957,678	456,701	27,809,092	88,310,069	60,957,678	0.031	-0.0034	0.223
108	201	72	345	14,244,820	41,956,926	77,452,108	456,701	28,100,873	105,096,280	77,452,108	0.028	-0.0034	0.239
114	195	72	351	13,407,303	43,428,750	95,380,837	456,701	28,418,026	123,342,162	95,380,837	0.024	-0.0035	0.256
120	189	72	357	12,595,157	44,925,947	114,743,864	456,701	28,760,552	143,047,715	114,743,864	0.022	-0.0035	0.274
126	183	72	363	11,808,384	46,448,515	135,541,189	456,701	29,128,450	164,212,938	135,541,189	0.019	-0.0036	0.293
132	177	72	369	11,046,983	47,996,457	157,772,812	456,701	29,521,720	186,837,831	157,772,812	0.017	-0.0036	0.313
138	171	72	375	10,310,954	49,569,770	181,438,734	456,701	29,940,362	210,922,396	181,438,734	0.014	-0.0037	0.334
144	165	72	381	9,600,298	51,168,456	206,538,954	456,701	30,384,377	236,466,630	206,538,954	0.013	-0.0037	0.356
150	159	72	387	8,915,014	52,792,514	233,073,473	456,701	30,853,764	263,470,536	233,073,473	0.011	-0.0038	0.379
156	153	72	393	8,255,102	54,441,944	261,042,290	456,701	31,348,253	291,934,112	261,042,290	0.009	-0.0038	0.403
162	147	72	399	7,620,562	56,116,746	290,445,405	456,701	31,868,654	321,857,358	290,445,405	0.008	-0.0039	0.428
168	141	72	405	7,011,395	57,816,921	321,282,818	456,701	32,414,158	353,240,275	321,282,818	0.007	-0.0040	0.454
174	135	72	411	6,427,599	59,542,468	353,554,530	456,701	32,985,034	386,082,863	353,554,530	0.006	-0.0040	0.482
180	129	72	417	5,869,177	61,293,387	387,260,540	456,701	33,581,282	420,385,121	387,260,540	0.005	-0.0041	0.511
186	123	72	423	5,336,126	63,069,679	422,400,848	456,701	34,202,902	456,147,049	422,400,848	0.004	-0.0042	0.541
192	117	72	429	4,828,448	46,871,342	458,975,454	456,701	34,849,895	493,368,649	458,975,454	0.003	-0.0043	0.572
198	111	72	435	4,346,142	66,698,378	496,984,359	456,701	35,522,260	532,049,916	496,984,359	0.003	-0.0044	0.605
204	105	72	441	3,889,208	68,550,787	536,427,562	456,701	36,219,997	572,190,859	536,427,562	0.002	-0.0044	0.639
210	99	72	447	3,457,646	70,428,567	577,305,064	456,701	36,943,107	613,791,470	577,305,064	0.002	-0.0045	0.674
216	93	72	453	3,051,457	72,331,720	619,616,863	456,701	37,691,588	656,851,751	619,616,863	0.001	-0.0046	0.711
222	87	72	459	2,670,640	74,260,245	663,362,961	456,701	38,465,443	701,371,703	663,362,961	0.001	-0.0047	0.749
228	81	72	465	2,315,195	76,214,143	708,543,357	456,701	39,264,664	745,351,326	708,543,357	0.001	-0.0048	0.789
234	75	72	471	1,985,123	78,193,412	755,158,052	456,701	40,089,267	794,790,619	755,158,052	0.001	-0.0049	0.831
240	69	72	477	1,680,422	80,198,054	803,207,045	456,701	40,939,238	843,689,582	803,207,045	0.000	-0.0050	0.874
246	63	72	483	1,401,094	82,228,068	852,690,336	456,701	41,814,581	894,048,217	852,690,336	0.000	-0.0051	0.919
252	57	72	489	1,147,139	84,283,455	903,607,926	456,701	42,715,297	945,866,521	903,607,926	0.000	-0.0053	0.965
258	51	72	495	918,555	86,364,213	955,959,813	456,701	43,641,384	999,144,497	955,959,813	0.000	-0.0054	1.014
264	45	72	501	715,344	88,470,344	1,009,745,999	456,701	44,592,844	1,053,882,143	1,009,745,999	0.000	-0.0055	1.064
270	39	72	507	537,505	90,601,847	1,064,966,484	456,701	45,569,676	1,110,079,451	1,064,966,484	0.000	-0.0056	1.116
276	33	72	513	385,038	92,758,723	1,121,621,266	456,701	46,571,881	1,167,736,441	1,121,621,266	0.000	-0.0057	1.169
282	27	72	519	257,944	94,940,970	1,179,710,347	456,701	47,599,457	1,226,853,104	1,179,710,347	0.000	-0.0059	1.225
288	21	72	525	156,222	97,148,590	1,239,233,726	456,701	48,652,406	1,287,429,432	1,239,233,726	0.000	-0.0060	1.283
294	15	72	531	79,872	99,381,583	1,300,191,404	456,701	49,730,727	1,349,465,431	1,300,191,404	0.000	-0.0061	1.342
300	9	72	537	28,894	101,639,947	1,362,583,380	456,701	50,834,421	1,412,961,100	1,362,583,380	0.000	-0.0063	1.404



Calculations are presented for the force on a single hydraulic cylinder used to pivot the block raiser table. An included graph shows how the cylinder force changes as the pivot is moved away from directly below the block c.g. towards the forks.

Calculations are also presented for the deflection of the block raiser table as a function of the pivot location for various distances between the pivot and the cylinder. For pivot locations near the center of the block (a block pivoter design rather than a block raiser) the

Included are the calculations of stress and deflection of a block raiser table made from steel plate material and supported at the pivot location.

Key conclusions are:

- 1) As the pivot location moves towards the forks, the hydraulic cylinder force increases rapidly.
- 2) Nearly independantly of pivot location, the stresses and deflections from a table made from steel plate are acceptably low. For a table with a pivot at the middle and fabricated from 1/4" thick steel material, the peak bending stresses are less than 5000 psi and deflections
- 3) The design to be detailed should be chosen to reduce the cylinder force and extension length to keep the cost of the cylinders down. Future work should explore using thinner steel plate (3/16") to reduce the table weight and therefore the cost.

**Peak Deflection for the Center Pivot Condition  
when table is horizontal**

